MODAL ANALYSIS TEST RIG FOR CLAMPED-CLAMPED BOUNDRY CONDITION

MOHD HAFIZ BIN RAZILAH

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Faculty of Mechanical Engineering

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project report and in my opinion this project is satisfactory in terms of scope and quality for the award of Diploma in Mechanical Engineering.

Signature:
Name of Supervisor: EN FIRDAUS BIN HASSAN
Position: LECTURE
Date:15 NOVEMBER 2011

STUDENT DECLARATION

I hereby declare that the work in this report is my own except for quotations and summaries which have been duly acknowledged. The report has not been accepted for any degree and is not concurently submitted for award of other degree.

Signature:
Name: MOHD HAFIZ BIN RAZILAH
ID Number: MB08089
Date:15 NOVEMBER 2011

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ABSTRACT

The main focus of this project is to design and fabricate a mini modal analysis test rig for clamped-clamped boundary condition. The design generation of this project and solid three dimensional structures modelling of the test rig was developed using solid work software. This test rig was made using iron angle and hollow square bar and went through a few fabricating process such as measuring, cutting, welding and finishing. It was successfully been done and able to support a modal analysis specimen for maximum length of plate is 20cm to 30 cm.

ABSTRAK

Fokus utama projek ini adalah untuk menghasilkan rig ujikaji untuk menjalankan modal analisis bagi sempadan yang dikepit pada kedua-dua belahnya. Generasi reka bentuk untuk projek ini dihasilkan melalui perisian solid work. Rig ujikaji ini dibuat daripada besi sudut dan bar berongga dan turut melalui beberapa proses seperti pengukuran, pengeratan bahan, proses arka dan penyudahan projek. Akhirnya projek ini berjaya disiapkan dan boleh menyokong modal analisis spesimen yang mempunyai panjang maksimum antara 20cm hingga 30cm.

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CHAPTER 1

INTRODUCTION

1.1 Background

This project is involves a design and fabricate process of a mini modal analysis test rig for clamped-clamped boundary condition. This test rig can clamp a plate for range 20cm to 30cm. This test rig also adjustable depend on the length of plate that want to use.This test rig is designed for a small and medium size of plate and not for a large scale of plate.The primary challenge in developing this project is to make it functions as an adjustable test rig. However, safety is a primary concern and the test rig must meet stringent strength and safety requirements. Modal analysis is the study of the dynamic properties of structures under vibrational excitation.Modal analysis, or more accurately experimental modal analysis, is the field of measuring and analysing the dynamic response of structures and or fluids when excited by an input. Examples would include measuring the vibration of a car's body when it is attached to an electromagnetic shake

1.2 Objective

The main objectives of this project is to design and fabricate a modal analysis test rig for clamped-clamped boundary condition that can clamp small plate to perform experimental modal analysis.

1.3 Problem Statement

To perform experimental modal analysis for plate,a modal analysis test rig has to be designed and fabricated.Currently, there is no test rig for plate available in FKM except test rig for large application such as cars,bikes and heavy duty machines.

1.4 Scope

1. Develop test rig that can clamp plates for range about 20cm to 30cm.
2. Adjustable for variety of usage
3. Total test rig weight around 2 to 3 kg.
4. The material used in fabricate of this test rig is mild steel.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Literature review of the project is totally highlighted in this chapter. In this chapter, there is a history and type of test rig. Besides that, it is consists with the design which were available in the industrial.

2.2 Type of Test Rig in Industrial

2.2.1 The Reciprocating Piston Test Rig

A model of the Reciprocating Piston Test Rig (RPTR) is shown in Fig. 2. This floating liner type test rig utilizes the crankshaft, piston, and cylinder block from a single-cylinder, 10hp engine. The 318 cc engine has a cylinder bore of 7.94 cm (3.125 inches) and a stroke of 6.43 cm (2.53 inches). A custom fixture was built to maintain accurate geometric locations for the engine components. A 2.2 kW (3hp) variable speed DC motor, located under the fixture table, drives the crankshaft through a set of pulleys. The toothed pulleys provide a speed reduction of 14:3, and the pulley connected to the crankshaft also acts as a flywheel to help reduce vibrations. A digital encoder, located on the opposite end of the crankshaft, records the angular position of thecrankshaft and can be used to determine piston location. A section of the cylinder block,containing the cylinder liner, is suspended from the rigid fixture above the crankshaft by two piezoelectric force sensors. The arrangement of the force sensors allows for the simultaneous measurement of piston position and friction forces in both the axial and thrust directions. The signals from the two Kistler 3-axis force transducers are amplified and then recorded along with the digital encoder signal through a National Instruments data acquisition board and software.

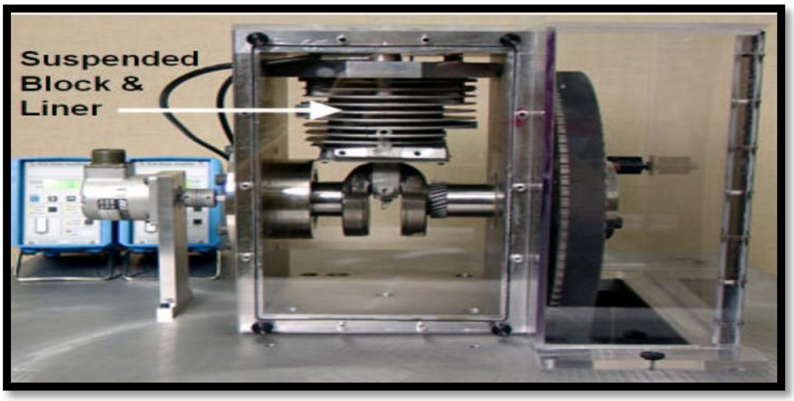

Figure 2.1: The Reciprocating Piston Test Rig

2.2.2 A Small Engine Dynamometer Test Rig

A bench scale dynamometer and the corresponding data acquisition system with measurement and control software were developed and built. The test rig has a capacity ofmotoring and braking at 10 hp with a maximum continuous torque of 39 Nm and a maximum speed of 5400 rpm. It is equipped with a torque sensor capable of measuring an average torque of up to 56.5 Nm and handling torque spikes of up to 226 Nm. A pressure sensor and an angular encoder with a maximum resolution of 0.09° are available for combustion pressure indication. For motored experiments the testing is operated and controlled automatically by the program developed using the LabView software. For fired tests a closed loop BMEP control with a servo throttle is available.

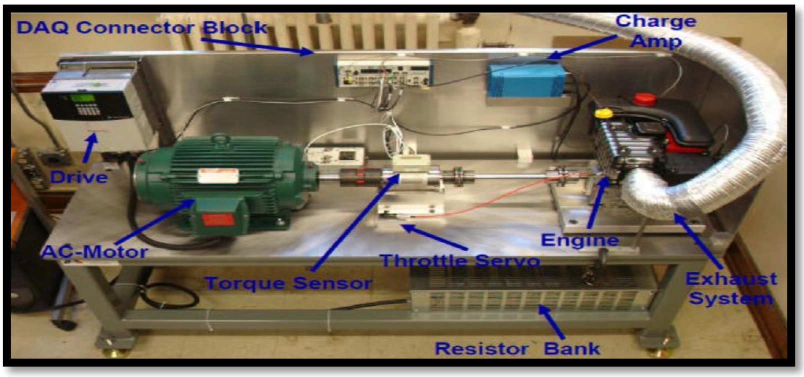

Figure 2.2: Small Engine Dynamometer Test Rig

2.2.3 Pin on Disk Test Rig (POD)

Rotation of the disk sample is controlled by a DC servo motor and a set of speed reducing pulleys located beneath the fixture table. The pin is held vertically by a balanced arm. A loadcell is used to measure the friction force. Normal force is applied by placing weights on the platform above the pin. A stationary proximity sensor, located on the fixture table, was directed toward a rotating steel target which was mounted to the bottom of the platen. The signal from the proxy sensor served as an index for the position of the specimen and was used to trigger thedata acquisition system at the beginning of each revolution. Data was acquired using a National Instruments board and a custom LabVIEW virtual instrument.

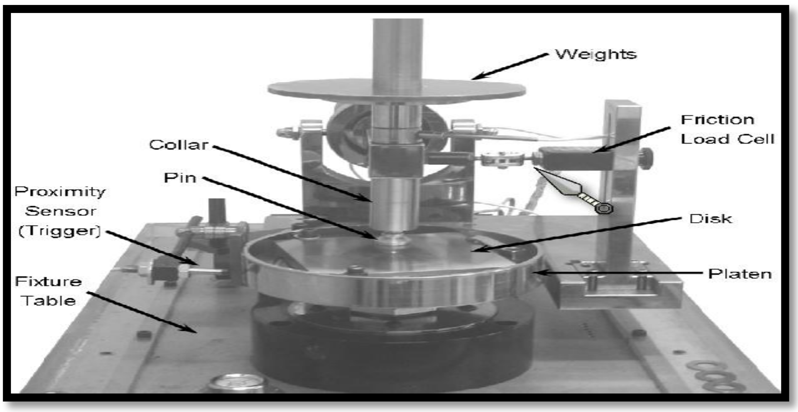

Figure 2.3 Pin on Disk Test Rig

2.2.4 Reciprocating Liner Test Rig (RLTR)

The RLTR simplifies the situation by neglecting piston secondary motion, thrust loads, multiple ring interactions, and the effects of combustion temperature and pressure. In the RLTR, a segment of a single piston ring is held stationary while a 60 degree section of a cylinder liner is reciprocated beneath it. Liner motion is provided by a slider crank mechanism with connecting rod and crank lengths comparable to those found in actual engines.

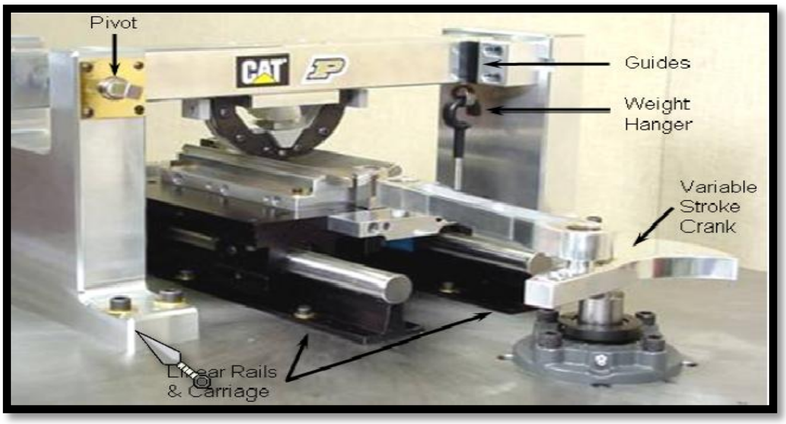

Figure 2.4: Reciprocating Liner Test Rig (RLTR)

2.2.5 Shear Driven Test Rig (SDTR)

SDTR includes: *i)* a 0.23N-m 1.8° stepper motor with an integrated controller, *ii)* amicropositioning table and *iii)* a stainless steel flat belt. The stepper motor used has a step resolution of 1/256, this allows 0.007° of rotation of motor output shaft for each step. This step resolution is necessary in order to be able to video the fluid flow out of microcavities at extremely low speeds. The micro-positioning table has a maximum travel distance of 6.4mm, and a resolution of 1_m. The stainless steel belt is 12.7mm wide, 0.0762mm thick and 280mm in circumference. There are three 20 mm diameter pulleys which guide the belt over the microcavity specimen. One of the pulleys is powered by the stepper motor and the other two are free rolling. Four posts are used to support and install the SDTR to the microscope table. Due to the limited space available on the microscope table, the SDTR is only 45mm wide, 84mm long and 84mm high.

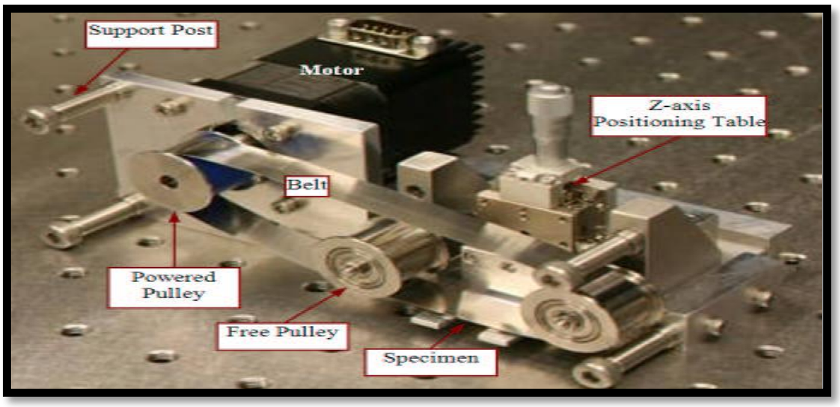

Figure 2.5: Shear Driven Test Rig (SDTR)

2.2.6 Lola Test Rig

Structural testing

Car wheels positioned on individual pans with chassis restrained to surface table.Wheel pans raised to stress suspension up to maximum expected loading.Simple load-versus-deflection plots used to show structural integrity and performance of suspension arms plus springs, dampers, torsion bars, anti-roll bars, and bump rubbers.Influence on corner weights throughout load range also recorded

Dynamic testing 4-post mode aerodynamic simulation via constant-rate force application using tensators .Full 7-post mode offers fixed or variable aerodynamic load testing with aero mapping.Track replay requires access to professional team engineers and budget

Figure 2.6: Lola Test Rig

2.2.7 Engine Diesel Test Rig

This unit mainly includes single-cylinder diesel engine, 4-stroke cycle, air cooling.Hydraulic brake, provided with electronic load cell for torque measurement,electronic pick-up for rpm measurement, base and vibration damping joints for engine supporting.Frame with bolts for floor fastening.Instrumentation:graduate burette for fuel flowrate measurement complete with feed pump,micromanometer connected to calibrated diaphragm for measuring combustion air flowrate, thermometer for measuring exhaust gas temperature, accelerator, main switch, tachometer, torque indicator.

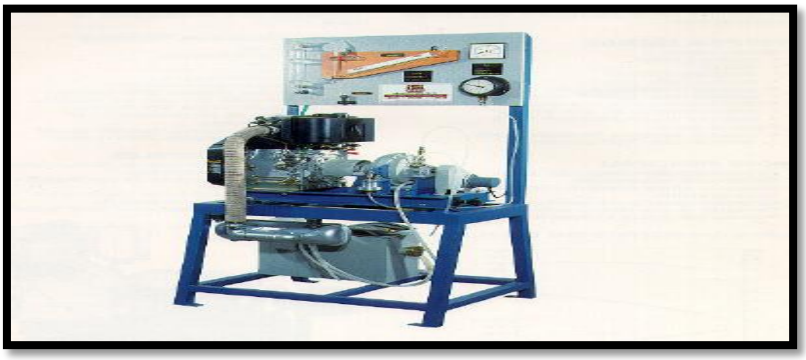

Figure 2.7: Engine Diesel Test Rig

2.2.8 Quarter-car Test Rig

A quarter-car test rig is used to study the behavior of vehicle due to the variation in road profile which is commonly known as ride analysis. The performance criteria in designing vehicle suspension system are body acceleration, suspension travel and wheel acceleration. Performance of the suspension system is characterized by the ability of the suspension system in reducing those three performance criteria effectively. The quarter car test rig should be developed in such a way that closely resembles the quarter part of a real vehicle. The quarter car test rig should have the ability to mount several different designs of actual car suspensions, able to perform a wide range of tests which include variation in body loads and the frequency of road disturbance, and still have the ability to expand for future developments.

A state-of-the-art quarter-car test rig has been designed and constructed to offer increased accuracy and testing flexibility at a reasonable cost which has the following features:

1. More realistic in representing the quarter portion of real vehicle compared with the existing quarter car test rig
2. The frequency of road disturbance can be easily adjusted
3. Variations in vehicle body and passenger masses can easily be simulated
4. Vertical and rotational dynamics of tire are considered in vehicle modeling to avoid a gross error in the representation of the actual vehicle response

5. To investigate the vehicle response in the presence of road disturbance
6. To study the damping characteristics of suspension system
7. To perform a study on the application of a control system to the rig for reproducing test vehicle response.

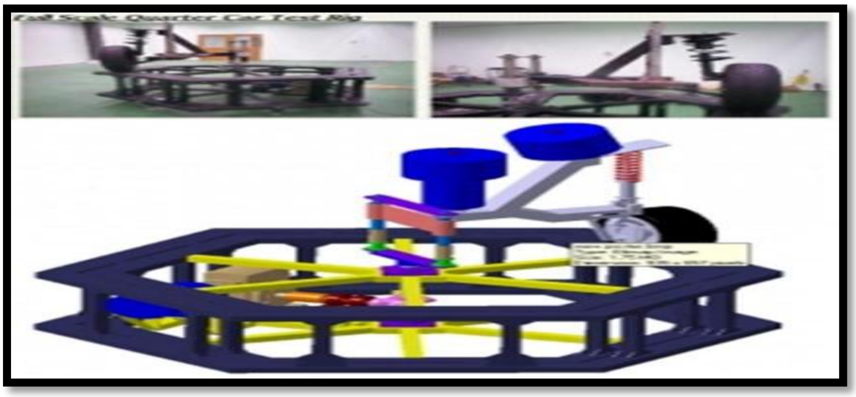

Figure 2.8: Quarter-car Test Rig

2.2.9 Pendulum Impact Test Rig

Pendulum impact test rig is designed and developed for simulating impact conditions experienced by structural component in real world crash or full scale crash test. The test rig can be adopted for crash testing individual vehicle component. The test rig comprise o a base plate which is anchored to a concrete ground, a pendulum supporting structure positioned on the base plate, a pendulum member constructed from structural T-beam that permanently secure to a rotatably shaft.

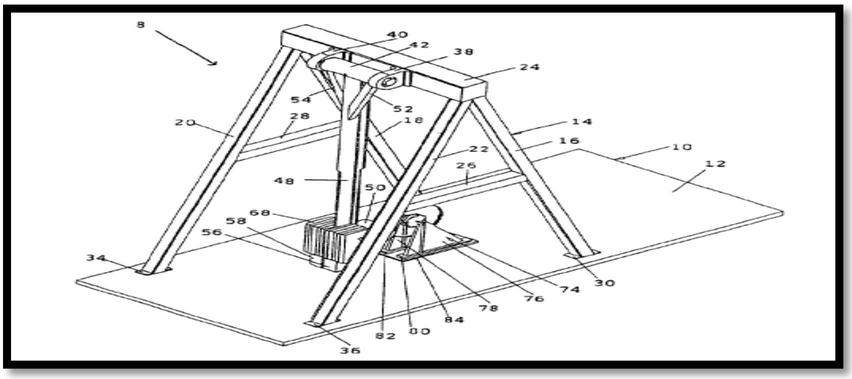

Figure 2.9: Pendulum test rig

i. Rotordynamic Test Rig for Rotor-Stator Rub Investigation

New rotordynamic test rig for rotor-stator rub investigation is built within scientific project *Nonlinear dynamics of rotational machinery* granted by Croatian ministry of education and science. Figure 2.9 shows design sketch and picture of the built rotordynamic test rig. From the Figure 2.9 it can be seen that test rig consists of the steel foundation, massive base plate elastically suspended and three subsystems mounted on it: drive, rotor and stator subsystem. Drive subsystem consists of the asynchronous electric motor rigidly mounted on the base plate and connected with the rotor via elastic coupling. Rotor subsystem includes shaft with three discs (two measuring discs and one for getting into contact with the stator) made from steel suspended on the base plate via two SKF roller bearings. Stator subsystem consists of stator ring , four circular beams and two stator casing foots rigidly connected to base plate. Two specially designed noncontact sensor supports are built in order to avoid measuring errors regarding support flexibility. First sensor support carries two Bruel & Kjaer Vibro IN 085 noncontacting displacement sensors for measuring rotor lateral movement in horizontal and vertical direction. Second sensor support carries three mentioned noncontacting displacement sensors; two for measuring stator lateral movement in horizontal and vertical direction and third noncontacting sensor for measuring torsional stator movement.